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(71) Applicant: SAMSUNG ELECTRONICS CO., LTD.
Suwon-City, Kyungki-do (KR)

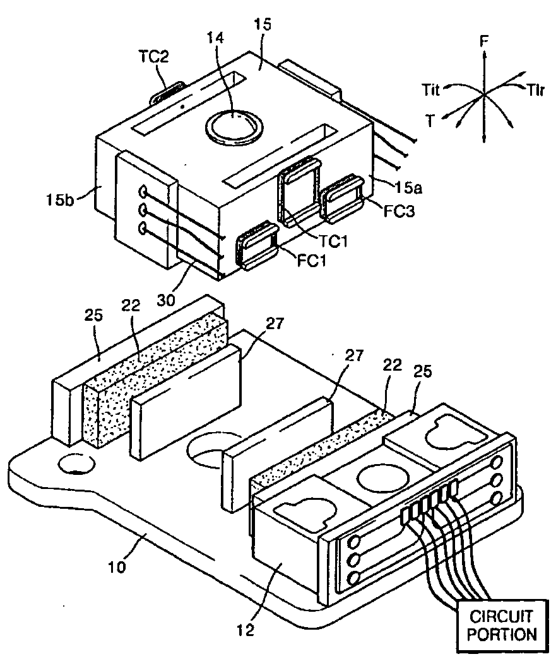
(72) Inventors:
- Song, Byung-youn
Paldal-gu, Suwon-si, Gyeonggi-do (KR)
- Nam, Do-sun
Suwon-si, Gyeonggi-do (KR)

(74) Representative: Robinson, Ian Michael et al
Appleyard Lees,
15 Clare Road
Halifax HX1 2HY (GB)

(54) Optical pickup actuator

(57) There is provided an optical pickup actuator having focus coils, track coils, and tilt coils (FC1-4,TC1 & 2) for driving a bobbin (15) in a focus direction, a track direction, and a tilt direction. The coils are distributed over two opposing sides of the bobbin (15), to secure the other opposite sides of the bobbin as free spaces. The free spaces on the other opposite sides of the bobbin on which the focus, track, and tilt coils are not disposed, thus allow supporting units (30) such as wires to be installed easily.

FIG. 3



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Description

[0001] The present invention relates to an optical pickup actuator, and more particularly, to an optical pickup actuator having focus coils, track coils, and tilt coils for driving a bobbin in a focus direction, a track direction, and a tilt direction.

[0002] In general, optical pickup actuators are adopted in optical recording/reproducing devices and move in a noncontact way in a radial direction along the recording media mounted on turntables to record/reproduce data on/from the optical disks.

[0003] Optical pickups include objective lenses for condensing light emitted from a light source to form a light spot on the optical disks and actuators for controlling the objective lenses in a track direction, and a focus direction, and a tilt direction to accurately position the light spot on the optical disks.

[0004] Optical pickup actuators include 2-axis driving actuators for driving the objective lens in the track and focus directions. However, as the numerical aperture of the objective lens increases for highly density recording and the wavelength of the laser beam is reduced, the tilt margin of the optical pickup actuators decreases. To compensate for this, 3-axis or 4-axis driving actuators for driving in the tilt direction as well as the track and focus directions are required. The 3-axis actuator allows driving in the focus, the track, and tilt radial directions. The 4-axis actuator allows driving in the focus, track, tilt radial, and tilt tangential directions. Referring to Figure 1, the focus, track, tilt radial, and tilt tangential directions are represented by L-L', M-M', N, and O, respectively.

[0005] Referring to Figure 1, a conventional optical pickup actuator includes a base 100, a holder 103 fixed on the base 100, a bobbin 107 having an objective lens 105, wires 109 for connecting the holder 103 to the bobbin 107, and a magnetic driver (not shown) for driving the bobbin 107 in the track and focus directions or the tilt direction.

[0006] The magnetic driver includes focus coils 110 and tilt coils 112 making two pairs with each other, track coils 115, first magnets 117, and second magnets 119. The focus coils 110 and the tilt coils 112 are positioned on the top and bottom sides 107a of the bobbin 107. The track coils 115 are disposed on the left and right sides 107b of the bobbin 107. The first magnets 117 and the second magnets 119 are installed on the base 100 to be spaced apart from the focus coils 110, the tilt coils 112, and the track coils 115. Outer yokes 118 and 120, which are installed on the base 100 and each fixes the first magnets 117 and the second magnets 119, are further included. Inner yokes 122, which are installed on the base 100 and opposite to the first magnets 117 to guide the bobbin 107, are also further included. The outer and inner yokes 118, 120, and 122 induce a magnetic field created by the first and second magnets 117 and 119 in a desired direction.

[0007] Wires 109 are soldered on two sides of the bobbin 107 and to the holder 103 to be electrically connected to a circuit unit (not shown), which applies current to the magnetic driver.

[0008] Figure 2A schematically shows the polarity of the first magnets 117 and the directions of currents to observe the relationship of the interaction forces between the focus and tilt coils 110 and 112, and the first magnets 117. Here, the focus coils 110 on two opposite sides 107a of the bobbin 107 receive a force F_f according to the Fleming's left-hand law so that the bobbin 107 moves in the focus direction L. The focus coils 110 receive a force in the opposite direction L' if the direction of the applied current is changed.

[0009] The tilt coils 112 make pairs with the focus coils 110 on the opposite sides 107a of the bobbin 107 to interact with the first magnets 117. Here, if the tilt coils 112 on the opposite sides 107a of the bobbin 107 are supplied with currents having the same intensity and opposite directions, they receive forces F_{ti} with opposite directions. Thus, the driving in the tilt direction, and particularly in a radial tilt direction N is performed.

[0010] Figure 2B schematically shows the polarity of the second magnets 117 and the directions of currents to observe the relationship of the interaction forces between the track coils 115 and the second magnets 117. The directions and magnitudes of the forces between magnets and coils are determined based on the Fleming's left-hand law. Thus, the track coils 115 on the lateral sides 107b of the bobbin 107 receive a force F_t in the track direction due to the second magnets 119 so that the bobbin 107 moves in the track direction M. Here, if the direction of the applied current is changed, the track coils 115 receive a force in the opposite direction M'.

[0011] Wires 109 of the optical pickup actuator generally include six wires for driving the bobbin in the focus, track, and tilt directions. A 4-axis driving actuator may require more wires. However, since an optical pickup actuator is very small, there is not enough space for installing the wires 109 if the four sides of the bobbin 107 are used to install the focus coils, track coils, and tilt coils. Also, if the number of wires increases, it is difficult to adhere the wires to the four sides of the bobbin 107 in such a narrow space. As a result, poor adhesion of the wires increases.

[0012] Moreover, if the four sides of the bobbin 107 are all used to dispose coils, the connection between coils becomes complicated. Also, since each of the focus coils, tilt coils, and track coils requires a magnet, the number of parts increases, and thus, the productivity decreases. Also, since the first magnets 117 for the focus coils 110 disposed on the left and right sides of the bobbin 107 may interfere with a spindle motor (not shown) for rotating a disk, the control of the spindle motor can be obstructed.

[0013] It is an aim of the present invention to provide an optical pickup actuator having focus coils, track coils, and tilt coils for driving a bobbin in a focus direction, a

track direction, and a tilt direction, while increasing free spaces on the bobbin.

[0014] According to the present invention there is provided an optical pickup actuator including a base, a bobbin, a holder, and a magnetic driver. The bobbin is disposed on the base to be moveable due to supporting units. The holder is positioned on one side of the base and connected to one ends of the supporting units. The magnetic driver has focus coils for driving the bobbin in a focus direction, track coils for driving the bobbin in a track direction, tilt coils for driving the bobbin in a tilt direction, and magnets installed to be opposite to the focus coils, the track coils, and the tilt coils. Here, the focus coils, the track coils, and the tilt coils are placed on opposite sides of the bobbin.

[0015] Ideally, the bobbin is generally rectangular. The focus coils, track coils and tilt coils are arranged on first and second sides of the bobbin, the first and second sides being opposite one another. Further, the supporting units, such as wires or leaf springs, are distributed on third and/or fourth sides of the bobbin. The third and fourth sides are opposite one another, and are perpendicular to the first and second sides.

[0016] Preferably, the magnets are four-polarization magnets. Alternatively, the magnets are at least two two-polarization magnets.

[0017] Preferably, the focus coils and the tilt coils are common coils. Alternatively, the focus coils and the tilt coils are separated coils. In either case, preferably, at least one of the focus coils, the tilt coils, and the track coils are fine pattern coils.

[0018] In a particularly preferred embodiment, the focus coils and the tilt coils are disposed to overlap each other.

[0019] Preferably, the supporting units are placed on the other opposite sides of the bobbin different from the opposite sides of the bobbin on which the focus coils, the tilt coils, and the track coils are placed. Preferably, the supporting units are wires or leaf springs.

[0020] Preferably, the optical pickup actuator further comprises outer yokes on which the magnets are fixed and inner yokes corresponding to the outer yokes.

[0021] Preferably, an objective lens is mounted in the bobbin.

[0022] For a better understanding of the invention, and to show how embodiments of the same may be carried into effect, reference will now be made, by way of example, to the accompanying diagrammatic drawings in which:

Figure 1 is a plan view of a conventional optical pickup actuator;

Figures 2A and 2B are diagrams showing the relationship between magnets and coils in the conventional optical pickup actuator shown in Figure 1;

Figure 3 is an exploded perspective view of an optical pickup actuator according to a first embodiment of the present invention;

Figure 4 is a plan view of the optical pickup actuator according to the first embodiment of the present invention;

Figure 5 is a diagram showing the relationship of the displacement of magnets and coils in the optical pickup actuator according to the present invention;

Figure 6 is a diagram showing the interaction forces between magnets and fine pattern coils in the optical pickup actuator according to the present invention; and

Figure 7 is an exploded perspective view of an optical pickup actuator according to a second embodiment of the present invention.

[0023] Referring to Figures 3 and 4, an optical pickup actuator according to a first embodiment of the present invention includes a base 10, a holder 12 positioned on one side of the base 10, a bobbin 15 with an objective lens 14, a magnetic driver for driving the bobbin 15 in each of the focus, tilt, and track directions.

[0024] The magnetic driver includes at least one focus coil for driving the bobbin 15 in the focus direction, at least one track coil for the driving in the track direction, at least one tilt coil for driving in the tilt direction, and magnets 22 opposite to the focus, track, and tilt coils.

[0025] For example, at least one focus coil may be composed of the first, second, third, and fourth focus coils, i.e., FC1, FC2, FC3, and FC4, respectively, and at least one track coil may be composed of the first and second track coils, i.e., TC1 and TC2, respectively. Here, the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4, control the driving in the focus and tilt directions. The magnets 22 are opposite to the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4, and the first and second track coils, TC1 and TC2. Here, the first, second, third, and fourth coils, FC1, FC2, FC3, and FC4, the first and second track coils, TC1 and TC2 are all disposed on some opposite sides of the bobbin 15. Supporting units 30, which apply current to the first, second, third, and fourth coils, FC1, FC2, FC3, and FC4 and the first and second track coils, TC1 and TC2 are placed on the other opposite sides of the bobbin 15. The supporting units 30 may be wires or plate springs.

[0026] The magnet 22 has four polarizations as shown in Figure 5. For convenience of the description, the four-polarization magnet 22 is divided into the first, second, third, and fourth polarizations 22a, 22b, 22c, and 22d. The first polarization 22a is a N pole, the second polarization 22b is a S pole, the third polarization 22c is a N pole, and the fourth polarization 22 is a S pole. The first, second, third, and fourth focus coils, FC1, FC2,

FC3, and FC4, and the first and second track coils, TC1 and TC2, are disposed to be opposite to the first, second, third, and fourth polarizations 22a, 22b, 22c, and 22d, respectively.

[0027] For example, the first and second track coils TC1 and TC2 are placed over the first and second polarizations 22a and 22b to be opposite to each other. The first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4, make two pairs with the track coils, TC1 and TC2, on the left and right sides of the bobbin 15 on which the track coils TC1 and TC2 are placed. In other words, the first and second focus coils, FC1 and FC2, may be placed over the second and third polarizations 22b and 22c to be opposite to each other, and the third and fourth focus coils, FC3 and FC4, may be placed over the first and fourth polarizations 22a and 22d to be opposite to each other too.

[0028] The magnet 22 may also be a two-polarization magnet. For example, two two-polarization magnets may be spaced apart from each other to be opposite to the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4.

[0029] Here, the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4, and the first and second track coils, TC1 and TC2, may be winding coils. Also, as shown in Figure 6, at least one of focus, tilt, and track coils may be a fine pattern coil 20. The fine pattern coil 20 is manufactured by patterning a coil on a film and is very useful for installation in a narrow space.

[0030] In the above-described embodiment, the tilt coils were shared between the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4. In other words, one coil controls the driving in both the focus and tilt directions. However, in a second embodiment, tilt coils may be included apart from the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4. As shown in Figure 7, the first, second, third, and fourth tilt coils, TiC1, TiC2, TiC3, and TiC4, are placed to overlap each other on positions similar to the positions of the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4. Here, the coils are placed in the form of first and second fine pattern coils 35 and 36.

[0031] As described previously, a magnet having four polarizations, 22a, 22b, 22c, and 22d is used as the magnet 22. The first and second focus coils, FC1 and FC2, are placed over the second and third polarizations, 22b and 22c, to be opposite to each other, and the third and fourth focus coils FC3 and FC4 are placed over the first and fourth polarizations 22a and 22d to be opposite to each other. The second fine pattern coils 36, which are formed by patterning the tilt coils TiC1, TiC2, TiC3, and TiC4, may be placed in front of or behind the first fine pattern coils 35, which are formed by patterning the first and third focus coils FC1 and FC3, and the first track coils TC1. Each of the two pairs of the tilt coils TiC1, TiC2, TiC3, and TiC4 may be placed on opposite sides 15a of the bobbin 15. In Figure 7, only the first and third tilt coils TiC1 and TiC3 are shown on one of the opposite sides 15a. However, the second and fourth tilt coils TiC2 and TiC4 are disposed on the other side of the opposite sides 15a.

[0032] The magnet 22 may have four polarizations with the same area. However, the first and second polarizations 22a and 22b, which are opposite to the first and second track coils TC1 and TC2, may have wider areas than the third and fourth polarizations 22c and 22d in order to secure wider effective areas of the first and second track coils TC1 and TC2. In other words, the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4, and the first, second, third, and fourth tilt coils TiC1, TiC2, TiC3, and TiC4 use the first, second, third, and fourth polarizations 22a, 22b, 22c, and 22d. However, the first and second track coils TC1 and TC2 use only the first and second polarizations 22a and 22b. Thus, the areas of the first, second, third, and fourth polarizations 22a, 22b, 22c, and 22d can be controlled to be equally distributed to the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4, the first, second, third, and fourth tilt coils, TiC1, TiC2, TiC3, and TiC4, and the first and second track coils, TC1 and TC2.

[0033] A neutral region 23 may be between the first, second, third, and fourth polarizations 22a, 22b, 22c, and 22d of the magnet 22. The neutral region 23 is positioned at the boundaries of the polarizations 22a, 22b, 22c, and 22d to prevent the weakening of the whole magnetic force due to offsets at contact points having different polarities.

[0034] Outer yokes 25 and inner yokes 27 may be further included to induce desired distribution of magnetic force lines generated by the magnet 22.

[0035] The operation of the optical pickup actuator having the above-described configuration will be described below.

[0036] First, a case where focus coils are shared between the tilt coils will be described. The drives in a focus direction F and a tilt direction T are performed due to the interaction between the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4, and the magnet 22.

[0037] Driving directions are determined based on directions of applied currents to the first, second, third, and fourth focus coils FC1, FC2, FC3, and FC4. One method is to apply current from the same power source to the first and second focus coils, FC1 and FC2, and to apply current from another power source to the third and fourth focus coils FC3 and FC4. Another method is to apply currents from four different power sources to the first, second, third, and fourth focus coils FC1, FC2, FC3, and FC4, respectively.

[0038] In the former method, the first, second, third, and fourth focus coils FC1, FC2, FC3, and FC4, respectively, receive forces in the same directions, which are directed upward or downward, respectively, due to the interaction with the magnetic field of the magnet 22 if currents having the same directions are applied to the first and second focus coils, FC1 and FC2, and the third

and fourth focus coils, FC3 and FC4, respectively. Thus, the driving of the bobbin 15 in the focus direction F can be controlled. In the later method, the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4, receive forces in different directions, which are directed upward or downward on the left and right sides of the bobbin 15 if current is applied to the first and second focus coils, FC1 and FC2, in the same direction, and current is applied to the third and fourth focus coils, FC3 and FC4, in a different direction from the first and second focus coils, FC1 and FC2. Thus, the driving of the bobbin 15 in the tilt direction can be controlled. Like this, 3-axis drives in the focus direction F, the track direction T, and tilt radial direction Tir are possible.

[0039] When current is applied from the same power source to the first and third focus coils FC1 and FC3, and current is applied from another power source to the second and fourth focus coils FC2 and FC4, the drive in a tilt tangential direction Tit can be performed.

[0040] The bobbin 15 moves upward and downward so that the drive in the focus direction F is performed when currents are applied from four different power sources to the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4 in the same direction, respectively.

[0041] The drive in the tilt radial direction Tir is performed if current is applied from the same power source to the first and second focus coils, FC1 and FC2, respectively, in the same direction, and current is applied from another power source to the third and fourth focus coils, FC3 and FC4, respectively, in a different direction from the first and second focus coils FC1 and FC2. If current is applied from the same power source to the first and third focus coils, FC1 and FC3, respectively, in the same direction, and current is applied from another power source to the second and fourth focus coils, FC2 and FC4, respectively, in a different direction, the drive in the tilt tangential direction Tit is performed.

[0042] The first and second track coils TC1 and TC2 interact with the first and second polarizations 22a and 22b to move the bobbin 15 in the track direction T. Thus, 4-axis drives in the focus direction F, the track direction T, the tilt radial direction Tir, and the tilt tangential direction Tit are possible.

[0043] As shown in Figure 7, the interaction relationship between coils and magnets will be described when the first, second, third, and fourth focus coils, FC1, FC2, FC3, and FC4, and the first, second, third, and fourth tilt coils, TiC1, TiC2, TiC3, and TiC4, are positioned on the same sides of the bobbin 15.

[0044] Current may also be applied from the same power source to the first, second, third, and fourth focus coils FC1, FC2, FC3, and FC4, respectively. In this case, the bobbin 15 may be driven upward or downward according only to the directions of current. The description of the first and second track coils TC1 and TC2 is the same as described previously and thus will be omitted.

[0045] Currents can also be applied from four different power sources to the first, second, third, and fourth tilt coils TiC1, TiC2, TiC3, and TiC4 so that the drives in the tilt radial direction Tir and the tilt tangential direction Tit are performed. In other words, if current is applied from the same power source to the first and second tilt coils, TiC1 and TiC2, and current is applied from different power source from the first and second tilt coils TiC1 and TiC2 to the third and fourth tilt coils, TiC3 and TiC4, the drive in the tilt radial direction Tir can be performed. If current is applied from the same power source to the first and third tilt coils, TiC1 and TiC3, and current is applied from different power source from the first and third tilt coils, TiC1 and TiC3, to the second and fourth tilt coils, TiC2 and TiC4, the drive in the tilt tangential direction Tit can be performed.

[0046] The arrangement of polarizations of the magnets and coils was described as only an example and may be modified in various forms without departing from the scope of the invention.

[0047] As described above, an optical pickup actuator according to the present invention has focus coils, track coils, and tilt coils on some opposite sides of a bobbin to secure free spaces on the other opposite sides of the bobbin on which the focus, track, and tilt coils are not disposed. Wires can easily be installed on the other opposite sides of the bobbin, poor adhesion of the wires to the bobbin can be reduced, and thus 3-axis and 4-axis drives can safely be realized.

[0048] The reader's attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0049] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0050] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings), may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0051] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. An optical pickup actuator comprising:

    a base (10);

    a bobbin (15) disposed on the base to be moveable due to supporting units (30);

    a holder (12) positioned on one side of the base and connected to one ends of the supporting units; and

    a magnetic driver having focus coils (FC1-4) for driving the bobbin in a focus direction, track coils (TC1,TC2) for driving the bobbin in a track direction, tilt coils (FC1-4) for driving the bobbin in a tilt direction, and magnets (22) installed to be opposite to the focus coils, the track coils, and the tilt coils,

    wherein the focus coils, the track coils, and the tilt coils are placed on opposite sides of the bobbin (15).

2. The optical pickup actuator of claim 1, wherein the magnets (22) are four-polarization magnets.

3. The optical pickup actuator of claim 1, wherein the magnets (22) are at least two two-polarization magnets.

4. The optical pickup actuator of any one of claims 1 through 3, wherein the focus coils and the tilt coils are common coils (FC1-4).

5. The optical pickup actuator of any one of claims 1 through 3, wherein the focus coils (FC1-4) and the tilt coils (TiC1-4) are separated coils.

6. The optical pickup actuator of any preceding claim, wherein at least one of the focus coils, the tilt coils, and the track coils are fine pattern coils.

7. The optical pickup actuator of any preceding claim, wherein the focus coils (FC1-4) and the tilt coils (TiC1-4) are disposed to overlap each other.

8. The optical pickup actuator of any preceding claim, wherein the supporting units (30) are placed on the other opposite sides of the bobbin different from the opposite sides of the bobbin on which the focus coils, the tilt coils, and the track coils are placed.

9. The optical pickup actuator of any preceding claim, wherein the supporting units (30) are wires or leaf springs.

10. The optical pickup actuator of any preceding claim, further comprising outer yokes (25) on which the magnets (22) are fixed and inner yokes (27) corresponding to the outer yokes (25).

11. The optical pickup actuator of any preceding, wherein an objective lens (14) is mounted in the bobbin.

FIG. 1 (PRIOR ART)

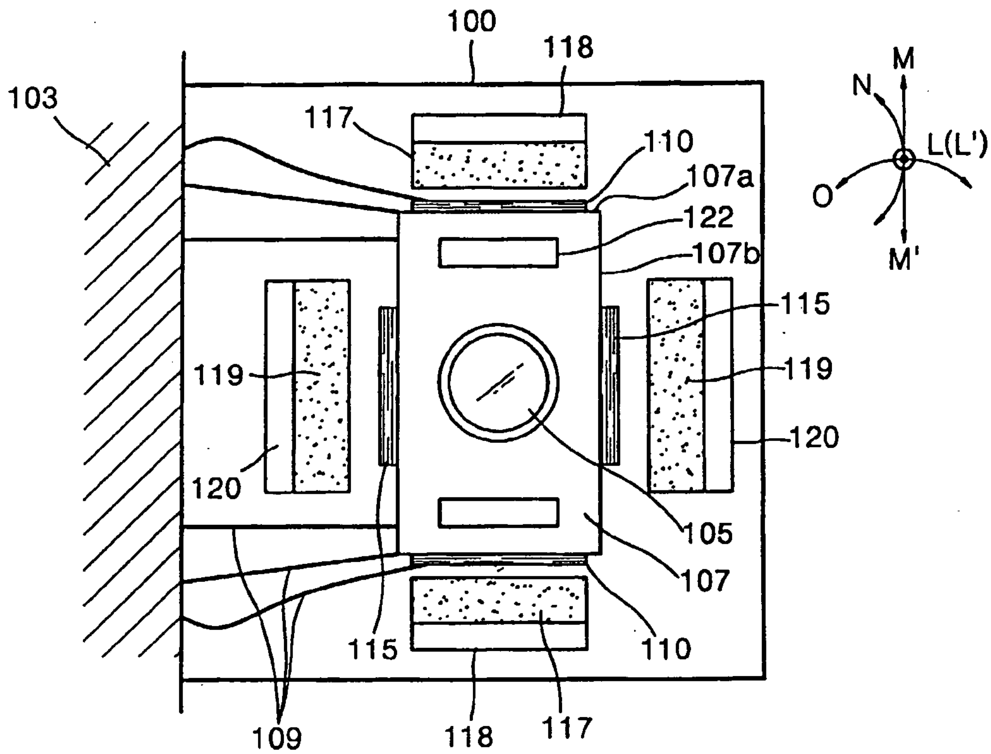


FIG. 2A (PRIOR ART)

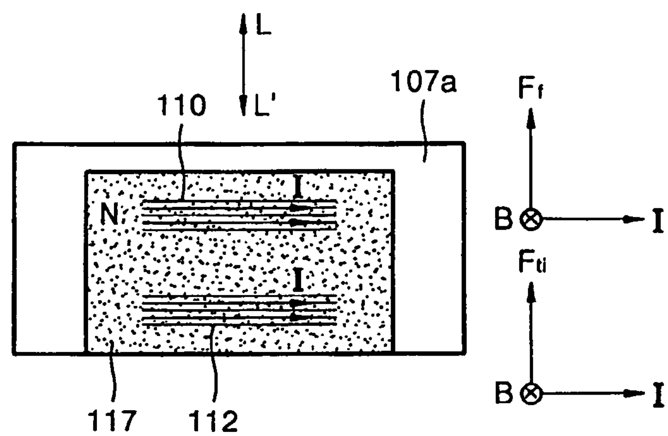


FIG. 2B (PRIOR ART)

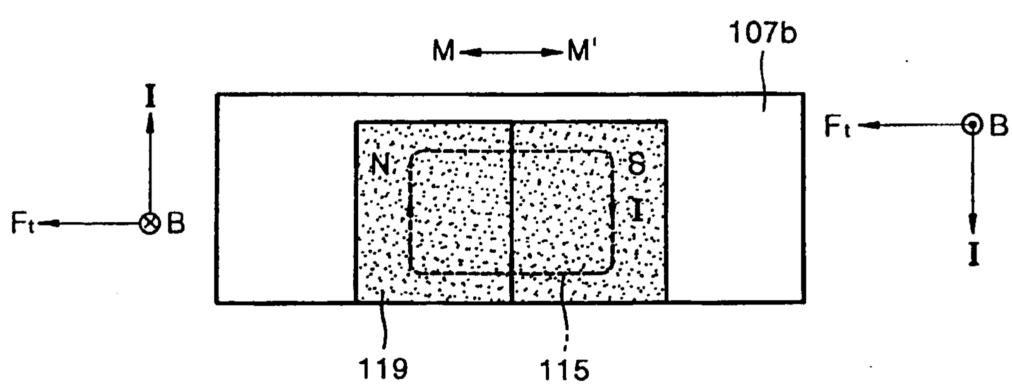
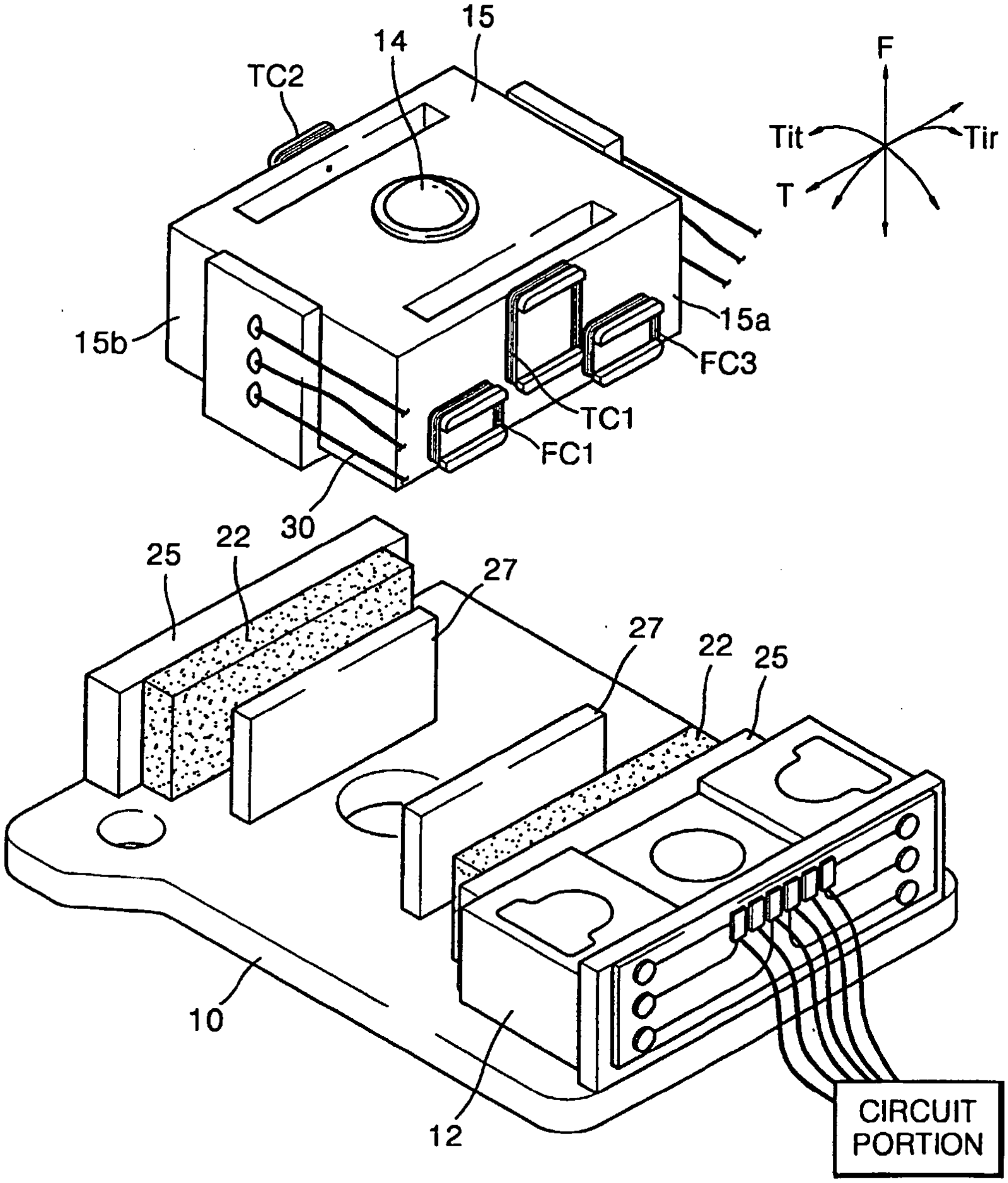


FIG. 3


15
14
TC2
F
Tit
Tir
T
15a
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FC3
TC1
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30
25
22
27
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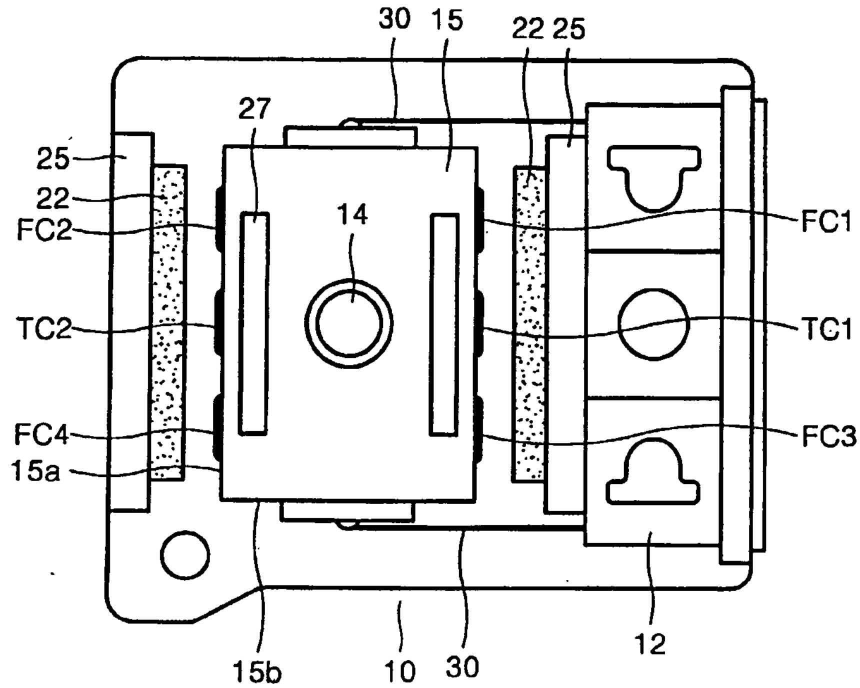
22
25
10
12
CIRCUIT PORTION

FIG. 4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22
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22
FC2
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FC1
TC2
TC1
FC4
FC3
15a
15b
10
30
12

FIG. 5

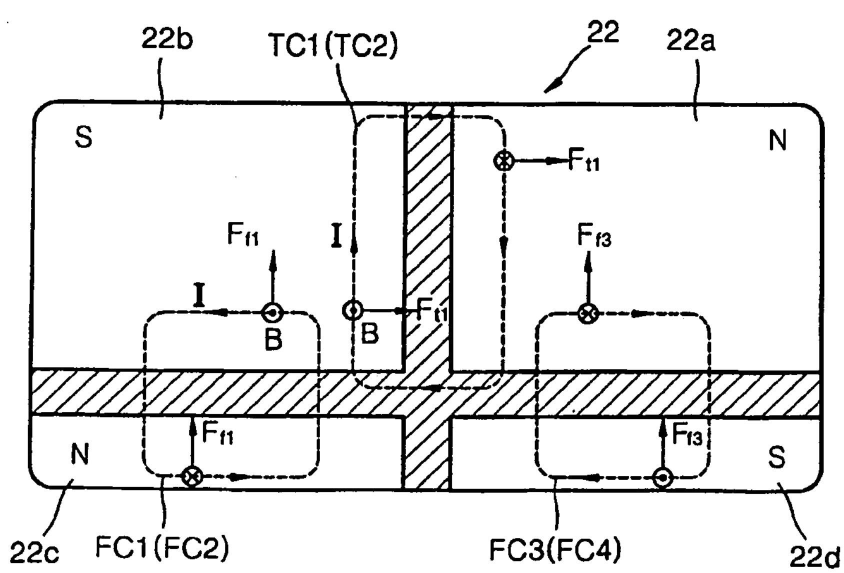

22b
TC1 (TC2)
22
22a
S
N
Ff1
I
Ff3
B
N
S
22c
FC1 (FC2)
FC3 (FC4)
22d

FIG. 6

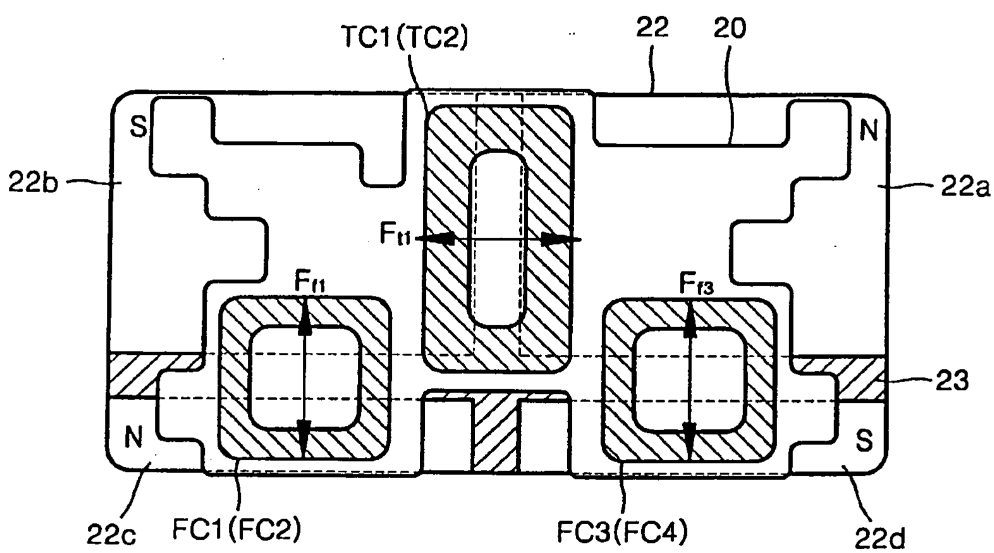
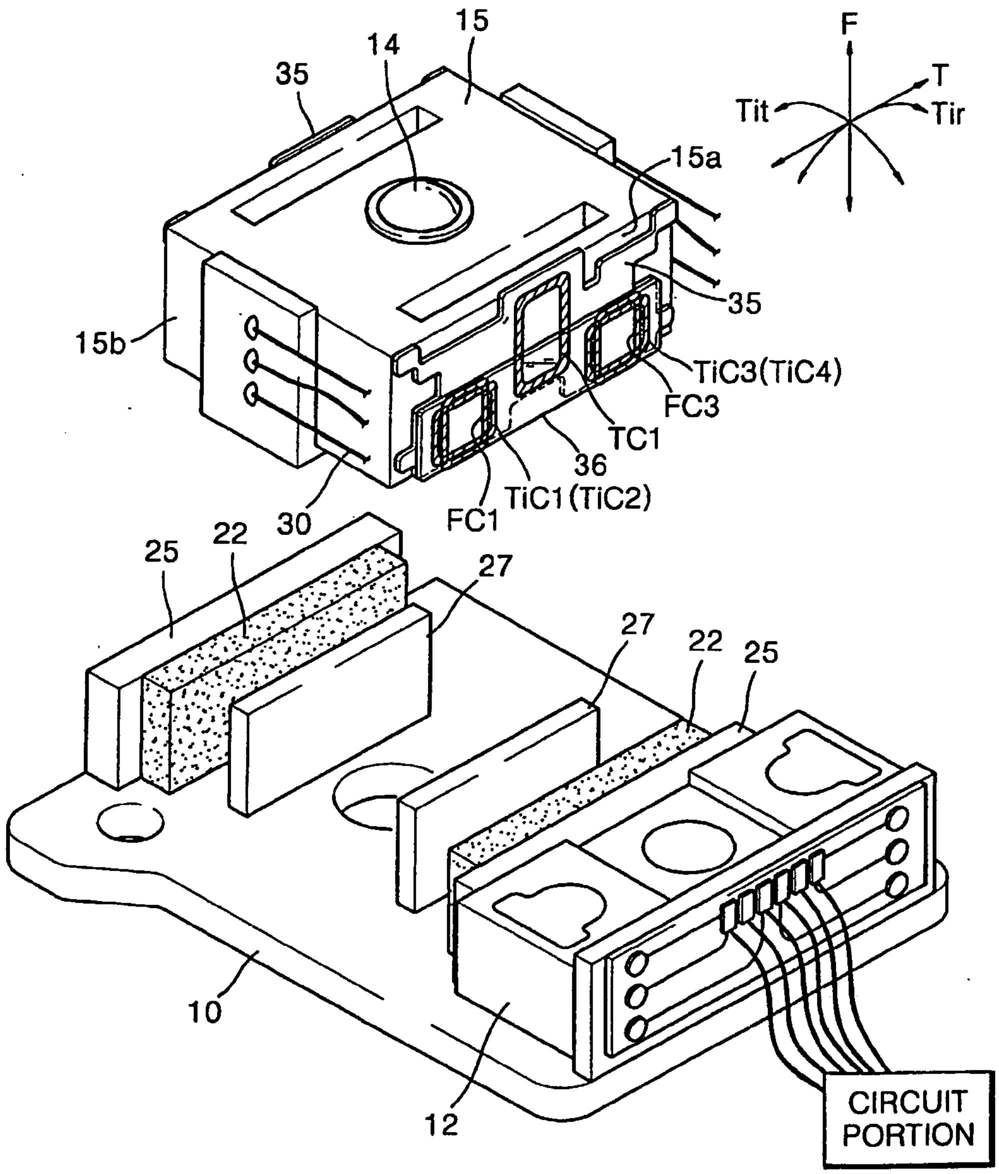


FIG. 7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T
Tit
Tir
15a
35
15b
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FC3
TC1
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30
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FC1
25
22
27
27
22
25
10
12
CIRCUIT
PORTION